

Figure 5  
Life Position

terial is moved from the foot to the mantle is remarkable. Undulating, wrinkling motions of the foot compact particles into mucus-bound strings in the furrows between the longitudinal and anteroposterior-oriented ridges. Particles compacted between these later ridges always travel posteriorly until they are removed from the foot. Particles compacted between the longitudinal ridges pass off ventrally. The foot is extremely sensitive to touch and stops these movements once it is clear of material. Apparently, this cleansing process relies only upon muscular undulations and does not require ciliation.

Material reaching the mantle is transported by cilia to the base of the inhalant siphon through which it is expelled from the mantle cavity by quick closure of the valves. There is one major ciliary tract on the mantle which runs posteriorly below the foot then posterodorsally around the end of the foot. This tract receives much of its material from several weaker, ventrally directed mantle tracts.

## DISCUSSION

*Myadora* exhibits structural similarities with a wide variety of pelecypods outside its own family. Its gill structure is similar to that of certain Tellinacea and other Pandoracea (RIDEWOOD, 1903; ATKINS, 1937; YONGE, 1949). YONGE (1949) believes an upturned outer demibranch lessens the probability that the gill will be choked by sediment and also makes particle sorting and transporting more

efficient. This gill structure may be a factor permitting *Myadora* to inhabit muddy substrata where it is likely that large amounts of resuspended sediment get drawn into the mantle cavity during feeding and respiration.

Separate siphons (or apertures) also occur in the Tellinacea, Erycinacea, Petricolidae, Tridacnidae and other Pandoracea. Their presence is often related to a group's feeding specialization, such as parasitism (Erycinacea) or surface deposit feeding (Tellinacea) (YONGE, 1949). In *Myadora*, the extensibility of the siphons may permit it to exploit suspended food resources from a variety of levels near the sediment surface. The mobility of the siphons, enhanced by their separation, could make food gathering more efficient by keeping the incurrent area away from the discharges of the excurrent siphon.

Although members of many other pelecypod groups have an anteriorly lobate foot, the writer knows of no other pelecypods that have a similar manner of foot cleansing. Like gill structure, this cleansing ability is probably an adaptation to life on muddy substrata.

The life position of *Myadora*, with the convex valve downward and with the commissure inclined away from the vertical, is typical of many inequivalved bivalves. Resting with the larger, convex valve downward may allow the siphons to protrude toward the surface without having to be sharply bent upward (STANLEY, 1970).

Compared to other members of the same genus, this species of *Myadora* is typical in terms of shell features. Compared to *Myochama*, it is very similar even though *Myochama* is a cemented, epifaunal form (STRANGE, 1848). Both *Myadora* and *Myochama* are markedly inequivalve and have similar gills and siphons. Unlike *Myadora*, *Myochama* usually has a strongly convex left valve and a small foot (HANCOCK, 1853).

Although *Myadora* and *Myochama* are structurally very similar to members of several pandoracean families (compare to descriptions by ALLEN, 1958), they are most similar overall to the Periplomatidae (Cretaceous-Recent) and Thraciidae (Jurassic-Recent). Like the Myochamidae, these families are largely composed of small, edentulous, strongly inequivalve forms that have a sinuate, continuous pallial line, external concentric ornamentation, recurved umbos, and a small, often internal ligament (Cox *et al.* 1969, figs. F26; F27). The presence of these similarities suggests that the geologically older Thraciidae or Periplomatidae may have given rise to the Myochamidae.

## CONCLUSIONS

*Myadora* is a shallow-burrowing, siphonate, filter-feeding pelecypod which has structural adaptations for life on

muddy substrata. The presence of several structural similarities with the Thraciidae and Periplomatidae suggests that one of these families may have given rise to the Myochamidae.

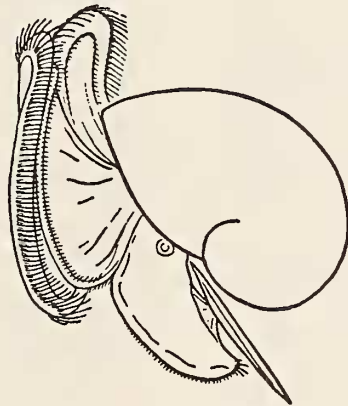
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# Notes on the Spawning and Larval Development of *Mitra idae* Melvill

(Gastropoda : Mitridae)

BY

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## INTRODUCTION

THE MITER SHELL, *Mitra (Atrimitra) idae* Melvill, 1893 is found from Crescent City, California to Cedros Island, central Baja California, Mexico (MCLEAN, 1969: 50). In the Monterey Bay area, California, we have found specimens of *M. idae* at Monastery Beach, Carmel Bay (also reported from here by ALLISON, 1959, as *Mitra (Atrimitra) montereyi* Berry, 1920) and along the Cannery Row area of Monterey at depths between 5 and 20 m.

CATE (1968) and CHESSE & ROSENTHAL (1971) have reported on the mating and spawning of southern California specimens of *Mitra idae*. We present further observations on spawning and larval development.

On April 21, 1973, while SCUBA diving approximately 100 m northwest of the Coast Guard breakwater at Monterey, a large adult *Mitra idae* (length 59 mm) was found moving over a sandy substrate in approximately 8 m of water. This was the only *M. idae* observed during the dive. The specimen was collected and held for 2 days in a 18 liter glass holding tank before being placed in a 180 l refrigerated marine aquarium with synthetic seawater at Diablo Valley College, Pleasant Hill, California. Salinity was maintained at 35‰, pH varied between 8.0 and 8.3, and water temperature average 13°C. The bottom of the aquarium was covered to a depth of 5 cm with gravel (size 3 mm) and several rocks were added.

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## OBSERVATIONS

Spawning began between May 4 and May 7, 1973. Capsules were deposited on a small granite rock. Although several rocks were in the tank, the rock on which the capsules were deposited was the only rock from the same locality as the *Mitra*. Also present on this rock were 3 sea anemones, *Anthopleura elegantissima* (Brandt, 1835), each approximately 2 cm in diameter. On May 10, the rock and capsules, along with the adult *Mitra*, were removed from the aquarium and placed in a 2000 ml beaker. The anemones were removed from the rock to prevent predation upon the *Mitra* larvae. (While removing the anemones, an entire *Mitra* egg capsule was regurgitated from the gullet of one anemone). The 2000 ml beaker was provided with a veliger trap modified after ECKELBARGER (1973).

Over a period of 17 days (May 6 to May 23) a spawn mass approximately 5×5 cm containing 173 capsules was deposited. Placement of capsules appeared random, however a group of 30 capsules deposited on May 21 were aligned in rows of 2. Mean capsule height was 8.3 mm. Capsule shape was as reported by CATE (1968: fig. 8) and CHESSE & ROSENTHAL (1971: 175).

Random capsules were removed periodically for egg counts and developmental observations. Capsules and eggs were preserved in 2% formalin (70% isopropyl alcohol caused the capsules to collapse and turn purple).

A mean of 927 embryos per capsule was found in 10 capsules examined. Embryos showing no cleavage, removed from newly deposited capsules, measured 160 μm

mean diameter. First cleavage was observed 5 hours after deposition of the capsule. Mobile trochophores, 200  $\mu$ m mean diameter, were observed in capsules 10 days after deposition, between 17 and 19 days, pre-veligers were visible.

When the capsules were first deposited, the embryos appeared to be randomly suspended in the albumen. As the albumen was consumed, larvae settled in the capsules. Veligers escaped 24 days after deposition through an apical plug which had disintegrated just prior to escape. The aperture of this apical plug varied between 950–1000  $\mu$ m in diameter. Veligers with a mean size of 250  $\mu$ m were found 48 hours after escape.

Comparison of the work of CHESSE & ROSENTHAL (1971) with the present study, or new observations by us, may be summarized as follows:

1) CHESSE & ROSENTHAL (1971: 174) found that "Egg capsules from different females are often distinguishable because capsule size varies proportionally with the size of a laying female." For a female of 59 mm length, we found mean capsule height to be 8.3 mm. This is from 1.0 to 1.5 mm greater than found by CHESSE & ROSENTHAL (1971: fig. 6) for southern California specimens of comparable length.

2) All capsules observed in this study were deposited on a near vertical surface. Preference for placement on near vertical surfaces was observed in the field by CHESSE & ROSENTHAL (1971: 174). Veliger settlement in the capsule caused the capsule to tilt downwards from its originally perpendicular position approximately 3 days prior to veliger escape, placing the apical plug in a downwards position, allowing the veligers to "fall" out of the capsule after disintegration of the plug.

3) The first 80 capsules deposited turned yellow within 24 hours after deposition. This yellow color resembles that observed by us in the capsules of *Nucella emarginata* (Deshayes, 1839) and *Acanthina spirata* (Blainville, 1832) deposited intertidally in the Monterey Bay area. The lack of this coloration in capsules subsequently deposited by the *Mitra idae* might be attributed to a deficiency either in the synthetic seawater or possibly in the diet of *M. idae* while in captivity. The embryos in both the yellow and

clear capsules were white in color and embryo development appeared to be the same in both yellow and clear capsules.

4) Based on a count of 5.7% of the capsules, total spawn was estimated at  $16 \times 10^4$  embryos (173 capsules with approximately 927 embryos per capsule).

5) THORSON (1950: 4) presents data indicating that marine bottom invertebrates, including prosobranchs, producing from  $1100-5 \times 10^8$  eggs per female per breeding season will have a long pelagic planktotrophic larval life. The spawn mass of  $16 \times 10^4$  embryos observed in the laboratory suggests a relatively long pelagic life for *Mitra idae*.

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# New Tertiary and Recent Naticidae From the Eastern Pacific

(Mollusca : Gastropoda)

BY

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(2 Plates; 3 Text figures)

IN THE COURSE of reviewing Miocene through Holocene Naticidae of the eastern Pacific (MARINCOVICH, 1973), three living and one extinct species were found to be unknown and are described here. Two living species, in the genera *Neverita* and *Choristes*, are from abyssal depths off of central Oregon, and one living species of *Polinices* is from the intertidal of the Galápagos Islands. These specimens represent only the fourth *Neverita* and the second *Choristes* known to be living in the eastern Pacific. In addition, a new species of *Natica* is reported from lower and middle Miocene strata of Oregon and Washington. Their description here makes them available for inclusion in taxonomic and other studies.

Abbreviations used in the text are as follows: AHF, Allan Hancock Foundation, University of Southern California, Los Angeles, gastropod collection on permanent loan to Los Angeles County Museum of Natural History; AMNH, American Museum of Natural History, New York, Department of Living Invertebrates; ANSP, Academy of Natural Sciences of Philadelphia, Department of Mollusks; CAS, California Academy of Sciences, San Francisco, Department of Geology; LACM, Los Angeles County Museum of Natural History; MCZ, Harvard University, Cambridge, Museum of Comparative Zoology; SDNHM, San Diego Natural History Museum, Department of Marine Invertebrates; SDSNH, San Diego Society of Natural History; SU, Stanford University, Stanford, Department of Geology; UCB, University of California at Berkeley; USGS, United States Geological Survey, Menlo Park, California; USNM, United States National Museum of Natural History, Washington, D.C.

NATICIDAE Gray, 1834

Polinicinae Finlay & Marwick, 1937

*Neverita* Risso, 1826

*Neverita (Neverita) lamonae* Marincovich, spec. nov.

(Figures 1, 4 and 5)

**Diagnosis:** *Neverita lamonae* is characterized by its elongate shape, thin shell, elongate umbilical callus, and shallow groove just below the suture.

**Description:**

**Color.** Shell exterior white, with narrow dark-brown or white band just below suture; interior, parietal callus and umbilical callus white. Periostracum light grayish brown.

**Shell.** Shell elongate, spire elevated, body whorl noticeably inflated, with a distinct, narrow, shallowly incised groove a short way below suture; shell thin; whorls  $4\frac{1}{2}$ , nuclear whorls not clearly differentiated, earliest nuclear whorl sunk into following whorl; suture moderately impressed. Spiral sculpture of minute, wavy, closely spaced costellae, absent from base and earliest  $1\frac{1}{2}$  whorls; axial sculpture of incremental growth lines. Parietal callus thick, moderately to heavily filling posterior apertural angle; anterior lobe weak but generally distinct. Umbilicus usually closed, may be narrowly open along entire margin. Umbilical callus elongate, with greatest width near or at

posterior end, smoothly merging with parietal callus; tapers anteriorly nearly to a point; callus evenly thins toward growing margin or more abruptly ends at an elongate marginal depression that may be deepest posteriorly. Umbilical area bounded anteriorly by low, sometimes indistinct rib on body whorl. Anterior inner lip thickened. Periostracum thin. Dimensions of holotype: height 18.5 mm, diameter 16.1 mm.

**Radula.** Each row of radular teeth consists of a rachidian flanked on each side by one lateral and two marginal teeth (Figure 1). Rachidian with three anterior cusps, the middle one slightly longer than the flanking cusps, and with two prominent basal processes. Lateral tooth elongate, with prominent median anterior cusp and smaller and sharper posterior median cusp. Inner marginal tooth with three anterior cusps, two of which are prominent and the third of which is very small. Other marginal tooth scythe shaped, simple.

**Operculum.** Chitinous, filling aperture.

**Type locality:** Off central Oregon at 44°34.8'N, 125°33.6'W, 2 816 m depth. Collected by Department of Oceanography, Oregon State University, R/V YAQUINA, sample BMT 186, March 16, 1970.

**Type material:** Holotype, USNM 741012; 1 paratype, USNM 741013; 1 paratype, LACM 1732; 1 paratype, CAS 55391; 1 paratype, AMNH 181738.

**Referred material:** One specimen, LACM, no accession number.

**Discussion:** *Neverita lamonae* most closely resembles *N. nana* (Möller, 1842), an offshore circumboreal species that ranges southward in progressively deeper water to Cabo San Quintín, western Baja California, in depths of 11 to 1 281 m. *Neverita nana* is smaller (maximum size: height 17.3 mm, diameter 14.8 mm, but usually much less) than *N. lamonae*, with a thinner parietal callus, more weakly impressed suture, less inflated body whorl, relatively thicker shell, and lacks a narrow groove below the suture and a depressed first protoconch whorl. In addition, the umbilicus of *N. nana* is always completely closed.

The holotype and all but one paratype were alive when collected. The holotype is the smallest known specimen, and the largest known specimen is 19.9 mm in height and 17.6 mm in diameter. The paratypes are from depths of 2 760 to 2 860 m in the vicinity of the type locality. All living specimens but one have a dark-brown band just below the suture. The lone exception has a white band instead of a brown one, which is still distinct by being more

brightly white than the rest of the shell. One paratype has a very narrowly open umbilicus along the entire growing margin of the umbilical callus. This feature is apparently atypical, because all other specimens have closed umbilici.

The radular dentition (Figure 1) does not have taxonomically useful characters at the species level. Its characteristics are shared by nearly all other eastern Pacific Polinicinae and Naticinae. It is presented here for comparison with the radulae of the *Choristes* species discussed below.

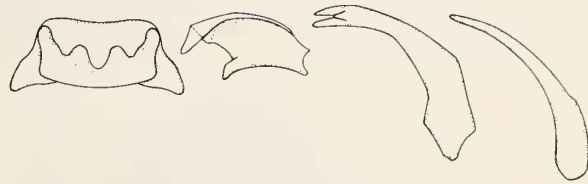


Figure 1

Radular dentition of *Neverita (Neverita) lamonae* Marincovich, spec. nov. LACM specimen

This species is named in memory of Kathy Lamon, a friend and fellow geologist killed in a helicopter crash on the Alaskan North Slope on June 30, 1974.

*Choristes* Carpenter, 1872

*Choristes coani* Marincovich, spec. nov.

(Figures 2, 6, and 7)

**Diagnosis:** *Choristes coani* is characterized by its low spire, narrowly and shallowly channeled suture, and faint spiral sculpture best developed below the suture.

**Description:**

**Color.** Shell exterior and interior whitish. Periostracum pale yellow to brownish white.

**Shell.** Shell globose, spire moderately elevated; body whorl not greatly inflated, narrowly flattened to slightly concave just below suture; shell thickness average; whorls 4½, nuclear whorls not clearly differentiated; earliest nuclear whorl sunken into succeeding whorl; microscopic radial wrinkles occur discontinuously below suture on nuclear whorls; suture slightly impressed. Spiral sculpture of very faint, minute, irregularly spaced costellae, slightly stronger near suture; axial sculpture of incremental growth lines. Parietal callus of average thickness, moder-